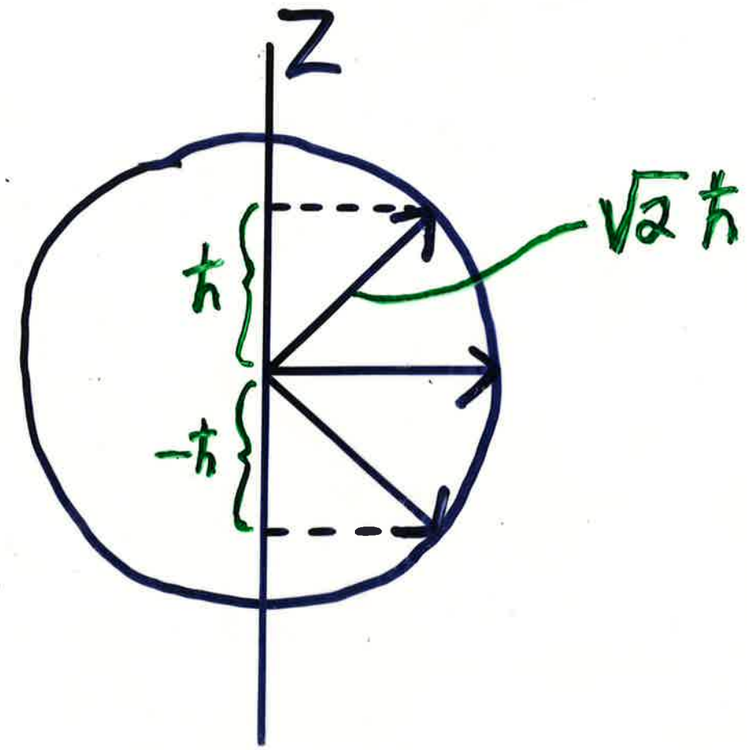
DIRECTIONAL QUANTIZATION

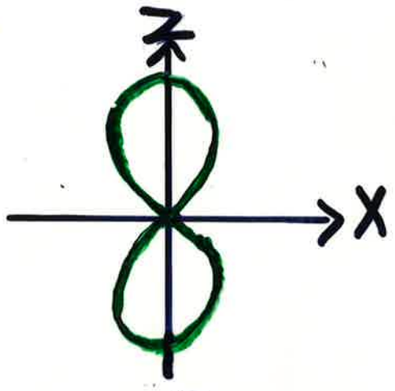
$\ell = 1$



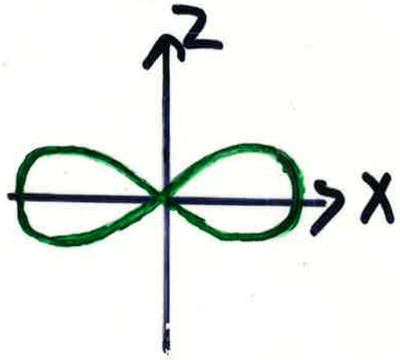
DIRECTIONAL QUANTIZATION IN THE HYDROGEN ATOM

(p states, $\ell = 1$)

$J_z = 0$



$J_z = \pm 1$



THE KOCHEN-SPECKER PARADOX

For $\rho = 1$, $[J_x^2] + [J_y^2] + [J_z^2] = 2$

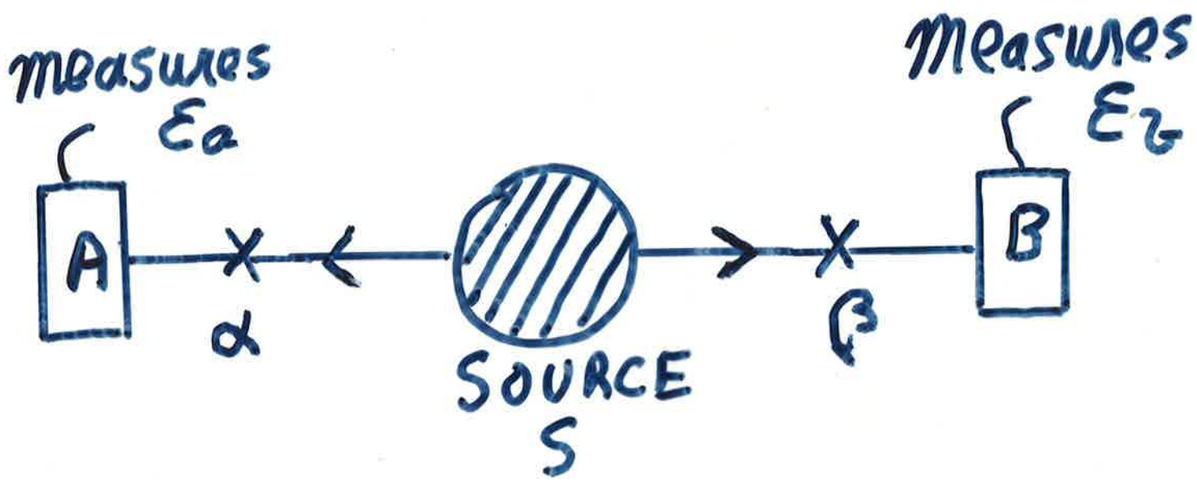
and $[J_x^2] = 0$ or 1, $[J_y^2] = 0$ or 1

$[J_z^2] = 0$ or 1

$\therefore$ 2 out of $[J_x^2], [J_y^2], [J_z^2]$ must have value 1.

1 out of $[J_x^2], [J_y^2], [J_z^2]$ must have value 0

THE BELL EXPERIMENT



$$\text{Prob}^{\eta_A, \eta_B, \eta_S}_{a, 2, \lambda}(\varepsilon_a, \varepsilon_2, \varepsilon_\lambda)$$

$$= \text{Prob}^{\eta_A, \eta_B, \eta_S}_{a}(\varepsilon_a \mid \varepsilon_2 \& \varepsilon_\lambda)$$

$$\times \text{Prob}^{\eta_A, \eta_B, \eta_S}_{2}(\varepsilon_2 \mid \varepsilon_\lambda)$$

$$\times \text{Prob}^{\eta_A, \eta_B, \eta_S}_{\lambda}(\varepsilon_\lambda)$$

COMPLETENESS

$$Prob_a^{\eta_A, \eta_B, \eta_S}(\varepsilon_a / \varepsilon_2 \& \varepsilon_\lambda) = Prob_a^{\eta_A, \eta_B, \eta_S}(\varepsilon_a / \varepsilon_\lambda)$$

LOCALITY

$$Prob_a^{\eta_A, \eta_B, \eta_S}(\varepsilon_a / \varepsilon_\lambda) = Prob_a^{\eta_A, \eta_S}(\varepsilon_a / \varepsilon_\lambda)$$

etc.

STRONG LOCALITY

$$P_{\mathrm{Born}}^{\eta_A, \eta_B, \eta_S}{}_{a,b,\lambda}(\varepsilon_a, \varepsilon_b, \varepsilon_\lambda)$$

$$= P_{\mathrm{Born}}{}_a^{\eta_A, \eta_S}(\varepsilon_a \mid \varepsilon_\lambda)$$

$$\times P_{\mathrm{Born}}{}_b^{\eta_B, \eta_S}(\varepsilon_b \mid \varepsilon_\lambda)$$

$$\times P_{\mathrm{Born}}{}_\lambda^{\eta_S}(\varepsilon_\lambda)$$

LOCALITY PRINCIPLE

The value of a physical quantity cannot be changed by altering the arrangement of a remote piece of apparatus

THE KOCHEN-SPECKER PARADOX (1967)

Corr. + Completion

→ Contradiction

where Corr. states:

Observables and self-adjoint operators are in 1:1 correspondence.

- Can be avoided by giving up Corr. (Van Fraassen 1973)

→ Deckhamized QM